TRAVIS

Comparison of Specifications For Steel Railroad Bridges

Civil Engineering
B. S.
1904

COMPARISON OF SPECIFICATIONS FOR STEEL RAILROAD BRIDGES

...BY...

Roy E Travis

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

ROY ELMER TRAVIS

ENTITLED COMPARISON OF SPECIFICATIONS FOR STEEL RAILROAD BRIDGES

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Civil Engineering

Ira O. Baker.

HEAD OF DEPARTMENT OF Civil Engineering

Introduction

It frequently happens that an engineer desires to know the requirements of a particular company concerning some feature of bridge construction, and it also frequently happens that engineer desires to make a comparison between different bridge specifications. The ordinary bridge specifications are presented in different order and in different typographical form, so that it is quite difficult to make these comparisons. Therefore the writer decided to present a summary of the leading features of the specifications of the principal railroads and bridge engineers in form suitable for ready reference and convenient for making the above comparisons. It is the hope of the writer that this thesis will be valuable not only in facilitating the comparison of different features, but that it will also show the extent of certain movements, as for example, the increase in train loading, the provision for impact, etc.

A list of the specifications included is

found upon pages 4 and 5 together with the date of specification. The dates indicate that most of the specifications have been re-written in the last four years. The requirements of the several specifications for different features are grouped upon succeeding pages. The summaries that follow present the main features of the several specifications, but there are a few minor points that have not been included, partly because they are relatively unimportant, and partly because only a few of the specifications consider any one of these minor items.

In the succeeding comparisons the different specifications are referred to by their number in the above list; and the omission of any number or the failure to insert any data for any particular specification is to be understood as meaning that that specification makes no requirements under that head.

In size the specifications vary from six to nine inches in width, and from nine to seventeen inches in length; although eleven of them are nominally eight and a half by fourteen inches, and seven are

practically six by nine inches. Those which are six by nine inches are bound at the side, while the others are bound at the end. Those which are in book form are much the more convenient.

Only a few of the specifications are well arranged; that is only a few have in one place all of the statements relating to the same subject, and only a few have cross references or a table of contents.

NO	DATE	NAME OF COMPANY.
1	1902	The Atchison, Topeka & Santa Fe Railway System.
2	1902	New York Central & Hudson River Railroad.
3	1903	The Delaware, Lackawanna & Western Railroad.
4	1901	Pennsylvania Railroad Company.
5	1902	Southern Railway Company
6	1901	Cooper's General Specifications.
7	1903	Illinois Central Railroad.
8	1900	Cleveland, Cincinnati, Chicago & St. Louis Railway.
9	1900	The Chicago & Alton Railway Company.
10	1900	Erie Railroad Company.
11	1901	Louisville & Nashville Railroad Company.
12	1903	The Wabash Railroad Company.
13	1900	Great Northern Railway Line.

NO	DATE.	NAME OF COMPANY
14	1900	American Bridge Company
15	1903	Osborne Engineering Company.
16	1903	Rock Island System.
17	1902	The Missouri Pacific Railway Company.
18	1903	Union Pacific Railroad Company.
19	1901	Lehigh Valley Railroad Company.
20	1903	Canadian Pacific Railway Company.
21	1902	Seaboard Air Line Railway.
22	1901	Chicago, Milwaukee & St. Paul Railway Company.
23	1898	Northern Pacific Railway Company.
24	1903	Chicago & North Western Railway
25	1896	Boston and Maine Railroad.
26	1903	American Railway Engineering and Maintenance of Way Association.

No	DIMENSIONS									
	Length in feet for which different kind of Bridges are used.				Clearance in feet.*					
	I Beam	Plate Girders	Riveted Truss	Pin Connected	W	C.	T	B	L	U
1	0 to 26	26 to 106	106 to 150	Over 150	14	23	7	10	4	4½
2	0 to 25	25 to 100	100 to 180	Over 180	14	21	7	10⅔	5	6
3	0 to 20	16 to 100	90 to 160	Over 150	14	22	7	11	4	5
4					14	20	6	10	4	5
5		0 to 105	105 to 135	Over 135	14	21½	6	10	4	4
6	0 to 20	20 to 75	75 to 150	Over 150	14	21	6		1	
7	0 to 25	25 to 100	80 to 125	Over 125	16	22	8	11	4	4
8	0 to 18	18 to 100	125 to 150	Over 150	14	22	8	10		5½
9	0 to 20	20 to 100	100 to 150	Over 150	16	25	7	10		5
10					15	22	7	11	5	5
11					14	22	6	10	5	4
12		0 to 80	80 to 120	Over 120	14	22	6	10	4	4
13					15	22½	7	10	4	6

* For explanation of nomenclature see p. 20

NO	DIMENSIONS									
	Lengths in feet for which different kind of Bridges are used.				Clearance in Feet.					
	I Beam	Plate Girders	Riveted Truss	Pin Connected	W	C	T	B	L	U.
14	0 to 20	20 to 100	100 to 140	Over 140.						
15					15	21½	8	11	5	6
16										
17	0 to 20	20 to 120	120 to 150	Over 150	15	22½	6	10	4	5½
18	0 to 19	19 to 100	100 to 150	Over 150	15	24	6	11	4	5
19	0 to 20	20 to 120	120 to 150	Over 150	14	22½	5½	10½	7½	4¾
20										
21	0 to 20	20 to 100	100 to 120	Over 120	14	22	6	10½	4	4
22										
23										
24										
25										
26										

NO.	QUALITY OF MATERIAL.								
	Chemical			Physical					
	% Phos.		% Sulp.	Ult. Strength lbs. sq in.	Elast. Limit.	% Elong.	% Red. Area	Bending On	Drift to
	Basic	Acid.							
1	.05	.08	.06	48-58000 55-65000	50% Ult. 55% Ult.	26	55	0 to t	1½ d
2	.04	.08	.05	48-56000 56-64000	28000 33000	28 26	50 55		1½d.
3	.04	.08	.04	62-70000 48-56000 54-62000	50% Ult.	22 28 26		0 to t	
4	.04	.06		48-56000 52-62000	28000	28 25	56 50	0 to t	1½d
5	.04	.06		60-68000 48-56000 54-62000	50% Ult.	22 26 25		0 to t	1½d
6	.04	.06		60-68000 50-58000 54-62000	50% Ult.	22 26 25		0 to 1½t	1½d
7	.04	.08	.04	50-58000 58-66000	30000 34000	28 20	50 40	0 to t	1½d
8	.04	.08	.06	54-62000 60-68000	33000 36000	26 23	50 43		
9	.04	.08	.06	62-70000 48-56000 54-62000	50% Ult.	22 28 26		0 to t	
10		.08		56-64000	58% Ult.	27	45	0 to t	1½d
11	.04	.08		62-70000 49-57000	50% Ult.	22 26	50		
12	.04	.08		65000 55000 60000	55% Ult.	25 26 25	50	0 to t	1½d
13	.04	.08		60-70000 48-56000 52-62000	55% Ult.	22 28 26		0 to t.	1½d

NO	QUALITY OF MATERIAL.								
	Chemical.			Physical.					
	% Phos.		% Sulp	Ult. Strength lbs. sq in.	Elast. Limit.	% Elong.	% Red Area	Bending On	Drift to
	Basic	Acid							
14	.05	.08		60-70000 48-58000 52-62000	50% Ult.	22 26 25		0 to t	1½ d.
15	.06	.08		60-70000 50-60000 52-62000	35000 30000 32000	22 26 25		0 to t	
16	.04	.08	.05	66000 60000 50000	36000 33000 25000	22		0 to t	
17	.05	.08		60-70000 52-62000 48-58000	50% Ult.	22 26 25		0 to t	1½ d.
18	.04	.08	.05	60-68000 48-54000	26000 23000	22 26	37	0 to t	
19	04	.06		60-68000 50-58000 54-62000	50% Ult.	22 26 25		0 to 1½ t	1½ d.
20		.06		58-65000	33000	20	40	0 to t	1⅛ d.
21	.05	.08		48-58000 55-65000	27000 33000	26 22		0 to t	1¼ d.
22	.06	.07	.06	60-68000 50-56000	55% Ult.	22 30		0 to t	1½ d.
23	.04	.08	.03	62-70000 52-60000	37000 30000	22 26		0 to t	1⅛ d.
24	.05	.08	.06	48-58000 55-65000	50% Ult. 55% Ult.	26 25	55 50	0 to t.	
25	.05			55-65000 60-68000	50% Ult.	25 23	45	0 to t.	1½ d.
26	.04	.08	.04-.05	45-55000 56-64000		22		0 to t.	

NO.	LOADS						
	Wt. of Track lbs. per lin. ft.	Concentrated	Wt. of Engine in Tons	Wt. on Axle in lbs.		Uniform per linear ft.	Impact*
				Maximum	Maximum Tender		
1		None	139-208½	66000	33000	4800	None
2	400	7'base 60 Ton.	142	40000	26000	4500	None
3	400	7'base 60 Ton.	167	50000	28000	4500	None
4		None.	158½	44000	30000	5000	$\frac{1-\frac{min}{max.}}{1+\frac{min}{max}}$
5	400-450	None	160	45000	30000	5000	$S\left(\frac{300}{L+300}\right)$
6	400	6'base 50-60 Ton		50000	32500	5000	None
7	420	7'base 56 Ton.	161½	46000	26000	4600	None
8	400	None		50000		5000	$S\left(\frac{10}{L+10}\right)$
9	400	7'base 60 Ton.	162½	50000	26400	5000	30% Beam & Str'n'g'rs.
10	400	None		35000	23000	4000	None
11		None	141	40000	28000	4500	None
12	350	None	177½	50000	32500	5000	$S\left(\frac{300}{L+300}\right)$
13	450	None	156	44000	24000	4000	$\frac{200}{L+150}$

* For explanation of nomenclature see p. 80

	LOADS						
	Wt of Track lbs per lin. ft.	Concentrated	Wt. of Engine in Tons	Wt. on Axle in lbs.		Uniform per linear ft.	Impact
				Maximum.	Maximum Tender		
14	400	None	142–177½	50000	32500	5000	$S\left(\frac{300}{L+300}\right)$
15	400	None	142–177½	50000	32500	5000	$S\left(\frac{S}{S+S_0}\right)$
16	450						
17	450		172½	50000	30000	5000	$L\left(1-\frac{1}{400}\right)$
18	500			55000	35000	5000	
19	400	None	177½	50000	32500	5000	$S\left(\frac{300}{L+300}\right)$
20				50000	32000	4000	
21	450		177½	50000	32500	5000	$S\left(\frac{300}{L+300}\right)$
22							
23							
24							
25	450			37000	24000	2500	
26							

UNIT STRESS IN SHEARING, BEARING, AND BENDING.

NO	Shearing		Bearing				Bending
	Webs.	Rivets	Rivets	Pins	Rollers.	Masonry lbs sq ft.	On Pins.
1	6000	7500	15000	15000	300d	300	18000
2	6000	6000	12000	12000	400d.	LL.250 DL.500	14000
3	6000	7500	12000	12000	300d	250	15000
4	13000net.	11000	26000	22000	3"min. 1200/d.	400	25000
5	10000	11000	22000	24000	3½"min. 1200/d	300	24000
6		9000	15000	15000	2⅞"min 300d.	250	18000
7	5000	8000	12000	16000	450d.	250	20000
8	6750	6750	13500	13500	400d.	300	16200
9	6000	7500	12000	12000	350d.	250	15000
10	4000	6000	12000	12000	300d	250	15000
11	10000	11000	22000	22000	2½"min. 1200/d.	400	25000
12	10000	11000		22000	600d	400	24000
13	12000	12000	20000	20000	3"min. 800d.	500	25000

NO.	UNIT STRESS IN SHEARING, BEARING, AND BENDING.						
	Shearing.		Bearing.				Bending.
	Webs.	Rivets.	Rivets	Pins.	Rollers.	Masonry lbs. sq. ft.	On Pins.
14	9000 s.s. 10000 m.s.	11000	22000	22000 s.s. 24000 m.s.	4" min √d.	400	22000 25000
15	9000 s.s. 10000 m.s.	10000	20000				25000
16							
17	10000	10000	20000	20000	3" min 800 d.	500	25000
18	6000	7500	15000	15000	400 d.	250 to 300	
19		9000	15000	15000	2 7/8" min. 300 d.	250	18000
20	9000	7500	12000	1200	3" min. 600 √d.	250	15000
21	10000	11000	22000	24000	1200 d	300	25000
22		9000	15000	15000	2 7/8 min 300 d	250	18000
23							
24					3 min 470 d.		
25	7210	9940	15000	15000	3 min 600 √d.	250	20000
26							

NO	UNIT STRESSES IN TENSION AND COMPRESSION.				
	Tension				Compression
	Main Members	Fl. Beam Stringers.	Fl. Beam Hng'rs.	Bracing	
1	LL. 9500 DL 19000	8000	6000	15000	$\frac{9000 \text{ to } 12000}{1 + \frac{\frac{l^2}{r^2}}{20000}}$
2	LL. 8000 DL 16000	8000 16000	5330 10660	16000	$1 - \frac{8000}{\frac{l^2}{18000 r^2}}$ L.L.
3	LL. 9000 DL 14000	8500 12500	7500	12000	$1 + \frac{8500}{\frac{l^2}{18000 r^2}}$ L.L. $\quad$ $1 + \frac{12500}{\frac{l^2}{18000 r^2}}$ D.L.
4	15000	15000	10000	15000	$1 + \frac{15000}{\frac{l^2}{13500 r^2}}$
5	17000	17000	17000	17000	Maximum 17000 med. 15000 soft.
6	LL 10000 D.L 20000	10000	6000	12000	$20000 - 90 \frac{l}{r}$
7	11000	10000	9000	15000	$1 + \frac{10000}{\frac{l^2}{18000 r^2}}$
8	9000	9000	9000	18000	$1 + \frac{9000}{\frac{l^2}{18000 r^2}}$ L.L.
9	L.L. 8000 D.L 12000	8000	7000	12000	$1 + \frac{7500}{\frac{l^2}{18000 r^2}}$ L.L. $\quad$ $1 + \frac{11500}{\frac{l^2}{18000 r^2}}$ D.L
10	8000	8000	8000	18000	$1 + \frac{18000}{\frac{l^2}{24000 r^2}}$
11	16000	15000	15000	15200	$1 + \frac{17000}{\frac{l^2}{11000 r^2}}$
12	16000	16000	16000	16000	$16000 - 70 \frac{l}{r}$
13	16000			16000	$1 + \frac{16000}{\frac{(12L)^2}{18 \text{ to } 36000 r^2}}$

NO	UNIT STRESSES IN TENSION AND COMPRESSION.				
	Tension.				
	Main Members.	Fl. Beam Stringers	Fl. Beam Hng'rs	Bracing	Compression.
14	15000 ss 17000 ms	15000 17000	15000 17000	15000 17000	$\frac{15000}{1+\frac{l^2}{13500r^2}}$ $\frac{17000}{1+\frac{l^2}{11000r^2}}$
15	15000 ss. 17000 ms.	15000 17000	15000 17000	15000 17000	$\frac{15000}{1+\frac{l^2}{18000r^2}}$ $\frac{17000}{1+\frac{l^2}{18000r^2}}$
16					
17	17000	17000	15000	17000	17000 − 80 l/r
18			6000	18000	18000 $8000(1+\frac{min}{max})$ − 35 to 45 l/r.
19	LL 10000 DL 20000	1000	6000	12000	20000 − 90 l/r.
20	10000	10000	10000	16000	$\frac{10000}{1+\frac{l^2}{20000r^2}}$ LL $\frac{10000}{1+\frac{l^2}{40000r^2}}$ DL.
21	17000	17000	17000	17000	$\frac{17000}{1+\frac{l^2}{11000r^2}}$
22	LL 9000 DL 18000	8000	6000	18000	20000 − 90 l/r.
23					
24					
25	10000			10000	$\frac{900}{1+\frac{l^2}{5000r^2}}$
26					

NO	Wind Loads.			Centrifugal Force	Combined Dead, Live & Wind Load & Centrifugal Force.	Eye Bar Steel	
	Dead	Live	Trestle			Minimum Ult. Strength.	Min. Elongation.
1	30 to 50	300		.03 Wd up to 5°	50%	55000	12½%
2	30-50	300		WVD * 85666.	25%	55000	10%
3					25%	58000	12%
4	30-50	300	300h * 130h 155 V	$220D\left(1+\frac{13}{5}\right)$	26⅔%	48000	14%
5	30-150	300		.03 Wd up to 5°	25%	58000	12%
6	150	450		60-3D	30%	56000	10%
7					25%		
8	30-50	350		180D lbs. per ft.	25%	58000	14%
9	125	300			33%	56000	12%
10						56000	15%
11						58000	12½%
12						65000	12½%
13					25%		

*For explanation of nomenclature see p. 20

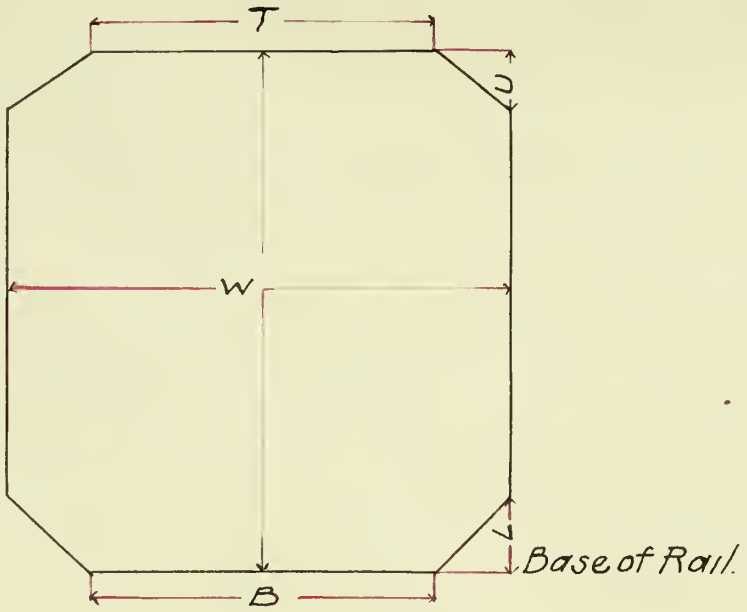
NO.	Wind Loads			Centrifugal Force.	Combined Dead, Live & Wind Load & Centrifugal Force.	Eye Bar Steel.	
	Dead	Live	Trestle			Minimum Ult. Strength.	Min. Elongation
14	30-50	300	30-50	.03 W.D. up to 5°	23½ - 26⅔ %	47-55000	10%
15	150	360	300	$\frac{WV^2}{32 2r}$	25%	55000	12%
16					25%	30-57000	12%
17	150	450		.03 W.D. up to 5°		43-55000	10%
18	30-50	300	150	.045 W.D. up to 5°	30%	54-68000	22-26%
19	150	450		60-3D	30%	56000	10%
20	30-50					58000	10%
21	30-50		500	02 L.L. up to 5°		55000	12%
22	30-50				30%	56000	10%
23							
24						55000	12½%
25	30-50		500		30%	56000	12½%
26							

NO	Reaming	NO	Planing
1	Field connections.	1	Beams and stringers.
2	All material except bracing.	2	Material over 1/2"
3	All field connections	3	Medium steel over 3/4"
4	Soft steel over 5/8" - Feild holes except bracing	4	Beams and stringers.
5	Material over 5/8" - Field holes except bracing	5	Material over 5/8"
6	Field holes except bracing	6	Medium steel
7	All field holes.	7	Medium steel
8	Soft steel over 5/8" - Field holes except bracing	8	Soft steel over 5/8" - Beams and stringers.
9	All field rivets	10	All material
10	Field holes	12	Medium steel.
11	Medium steel	13	Beams and stringers
12	Field rivets	17	All web plates subject to tension
13	All field rivets - Floor connections.	19	Medium steel
15	All field rivets - Floor beams and stringers.	20	Sheared edges.
17	All field rivets - except lattice bars	22	Roller beds.
18	All field rivets in truss.	26	Sheared edges and ends.

NET SECTION.

NO.	Specifications.
1	Deduct all holes in diagonal section unless there is 30 % excess area.
2	Least line of resistance.
5	Deduct holes whose centers are within 1 3/8" of any plane.
6	Deduct all holes in diagonal section unless there is 30% excess area.
8	Deduct hole within 1" of any plane.
9	1½ times body of member.
12	All rivet holes ⅛" larger than rivet.
13	Rivet holes ⅛" larger than rivet.
17	Deduct holes within 1" of plane.
19	Deduct all holes in diagonal section unless there is 30% excess area.
21	Deduct holes within 1" of plane.

Clearance Diagram.



Loads.

L = Length of loaded distance.
S = Maximum live load stress
S_D = Maximum dead load stress.

Wind Loads.

h = Horizontal linear foot.
V = Vertical linear foot.

Centrifugal Force

W = Weight of Train.
V = Velocity miles per hour.
D = Degree of curve.